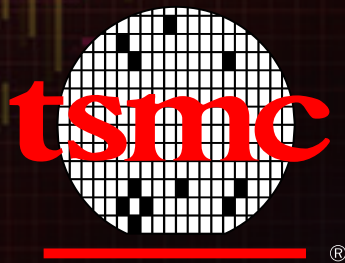


Enabling Smart Homes & Wearables with New Bluetooth IC Architectures on the Proper Technology Nodes

Synopsys



TSMC 2016
Open Innovation Platform®
Ecosystem Forum

ABSTRACT

It is estimated that by year 2020, there will be over 33 billion connected devices from edge to the cloud in the IoT environments. Out of numerous technologies, wireless connectivity has emerged as a key enabler of connected devices such as mobile phones, wearables, smart homes, smart cities, and in almost anything that can deliver information to add value to our lives. However, the market has thus far experienced difficulties getting over interoperability hurdles, cost & power hurdles and in many cases providing enough value to the consumer. Designers continue to leverage old designs in mobile, automotive, and PC markets to address these problems but there are numerous initiatives to tackle these problems including how to best architect the overall design of the SoCs.

Bluetooth low energy has been an ideal choice for solving the interoperability issue and now is moving beyond the nearable applications and into our homes and possibly beyond. As for the cost and power hurdles, architects will need to look at the overall system costs and dive deeper into aligning the proper technologies available.

Synopsys offers a complete Bluetooth low energy IP as well as an 802.15.4 PHY and it has been collaborating with TSMC to provide designers with multiple technology options to address IoT design challenges. TSMC's 40ULP IoT process technology combined with Synopsys' solutions with integrated matching network, low voltage operation, and small area enables a new paradigm in the industry that supports the latest Bluetooth specifications targeted both at Nearable and Smart Home applications.

This presentation will focus on system and SoC architectures and how they are moving to integrate wireless IP to reduce component count, power, & costs. We will focus particularly on how the Synopsys and TSMC collaboration to address these design challenges will help designers overcome hurdles described above so they can focus on providing much more value to their customers which in turn will proliferate smart home and wearable markets into growth opportunities.

Enabling Smart Homes & Wearables with New Bluetooth IC Architectures on the Proper Technology Nodes

Ron Lowman
September, 2016



Wearables

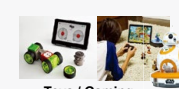
Personal / Nearable
(Bluetooth Has Become Defacto Standard)



Fitness Bands	Baby Wearables
<p>Fitbit Charge 5</p> <p>Price: \$129.99</p> <p>Features: Heart rate monitoring, sleep tracking, stress management, 30-day battery life.</p>	<p>Philips Avent SCD561</p> <p>Price: \$149.99</p> <p>Features: Real-time monitoring, sleep tracking, feeding tracking, 10-hour battery life.</p>



Sports



Toys / Gaming

Portable Health: Blood Glucose, Oximeters, Blood Pressure, Thermometers, Toothbrush, Hearing aids



Smart Home

Automation, Lighting, & Security (Bluetooth 5.0 Targets)



Door Locks

Lighting

Home Automation

Beacons

- Proximity & Navigation
- Asset Tracking
- Location Awareness
- Marketing & Ads
- Public Information



Bluetooth Router

(Cassia Networks & Eero)



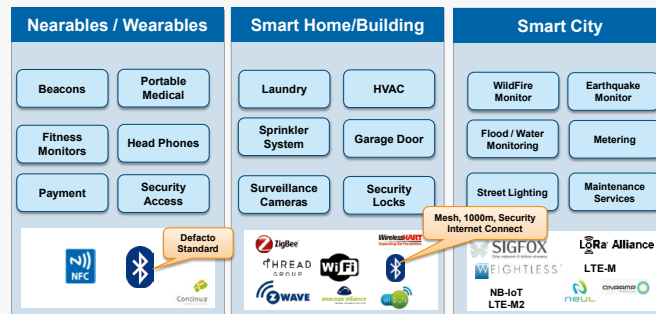
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SYNOPSIS®

IoT Edge Device Connectivity

Different Applications Require Different Solutions

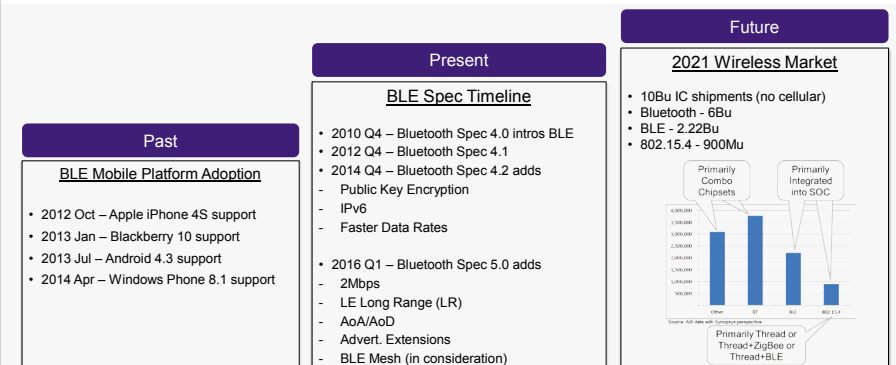
>50% of IoT Growth Expected from Wearables & Smart Home



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Wireless Market Related to Bluetooth



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Bluetooth Low Energy Evolution

Key Features of Bluetooth 4.2 & Bluetooth 5.0 Enhancements



Benefits	Features	End user example
Flexible Internet Connectivity options	Low-power IP (IPv6/6LoWPAN) Available through the Internet Protocol Support Profile (IPSP)	A Bluetooth low energy sensor can access the Internet (send and receive messages) through a gateway device
Industry-leading Privacy	LE Privacy 1.2	A Bluetooth low energy location tracker can only be followed by the owner or trusted group all while consuming less power
Highly Secure	LE Secure Connections	A Bluetooth low energy lock or other smart home device provides industry standard security for added user confidence during device pairing
Data Throughput Increase	LE Data Length Extension Up to 2.5x faster with a packet capacity increase of 10x vs. previous versions	Over-the-air firmware updates for a Bluetooth low energy device are up to 250% faster and more reliable

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Bluetooth Low Energy Evolution

Key Features of Bluetooth 4.2 & Bluetooth 5.0 Enhancements



Addressing whole home, building, or property coverage

SIG Proposed Solutions	Feature Name	Improvements
Better receiver sensitivity	LE Long Range	Improving Sensitivity by 12dB by coding (FEC)
Multi-hop network topologies	Bluetooth Mesh	New Profile under development by Smart Mesh Working Group
Higher transmit output power	LE Higher Output Power *	Increasing the max. TX output power from +10dBm to +20 dBm

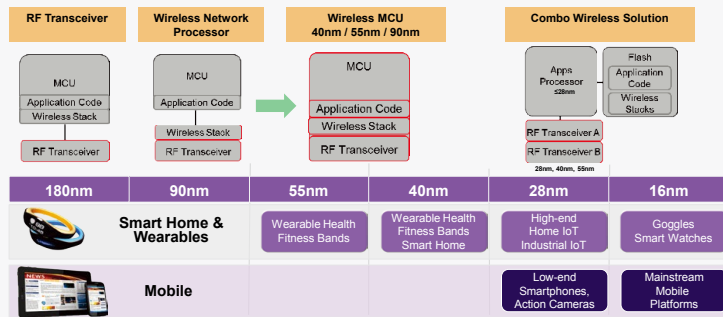
* Increasing output power to +20dBm aligning with BR/EDR and competing standards (e.g., 802.15.4) in the US smart home market. Some regulatory regimes will not allow > +10 dBm output power. Therefore, the modifications to the specification indicates that output power is limited by the regulatory regime applicable.

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Process Technology Trends

Radio System Architectures & Integration Options



BLE, 802.15.4, WiFi, & IoT 3GPP Radio Integration Is Aligned at 40nm & 55nm

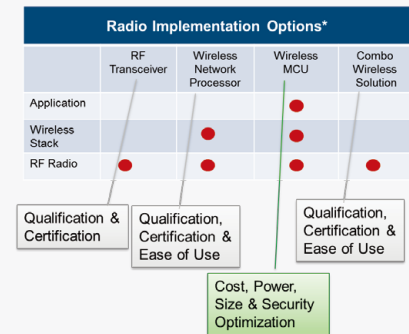
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The Benefits of Integrating RF

SoC Integration vs Off-Chip

- Improve Latency
- Reduce Power
- Reduce Costs
- Reduce PCB Size
- Memory Use Optimization
- Security
- Your Competition is already doing this

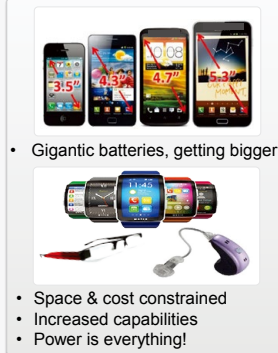


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Energy Efficiency

Energy Costs Require Innovation



Device	Power	Battery	Duration
Google Glass	570mAh	Li Polymer	1 days
Samsung Gear S Smart Watch	300mAh	Li-Ion	1-2 days
Samsung Gear Fit Smart Watch	210mAh	Li-Ion	3-4 days
Starkey Hearing Aid	91- 630mAh	Zinc Air	3-22 days
Bluetooth Beacon	225mAh	Lithium	Several month

Off-the-shelf vs Custom ASIC:
Other wearables can benefit from innovation found in hearing aids

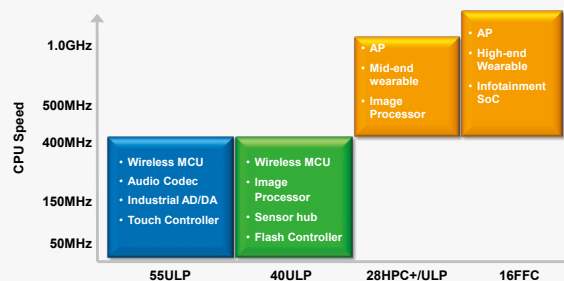
Synopsys Acquires Bluetooth Low Energy IP



- Silicon-proven Bluetooth® low energy IP supporting latest standards
- Supports down to one-volt operation for extended battery life
- Expands Synopsys' extensive DesignWare IP portfolio for IoT
- Complements existing expertise in Analog & RF

Synopsys and TSMC Collaborate to Enable IoT Designs

Reference Subsystem Platform on TSMC 40ULP for IoT and Wearable Applications



Source: Feb3, 2016 Synopsys/TSMC webinar

Synopsys Analog and RF Expertise

Easing Integration Efforts

Gen. Purpose ADCs for MCU		12 & 14-bit ADCs for general purpose measurements in the SoC
Bluetooth, 802.15.4		Deploying complete BLE & 802.15.4 PHY Membership of Bluetooth SIG & Thread
LTE-M1, LTE-M2 NB-IoT, etc.		Developing optimized LTE-M AFE
WiFi 802.11		AFE for 802.11n/ac/ax baseband supporting BW up to 160MSPS
LTE for Cellular		LTE/LTE-A AFE baseband, up to 5 aggregated channels (100MSPS) LTE cat-0 AFE baseband
5G for Cellular		AFE to support 5G applications. Giga-SPS data converters

Bluetooth 5.0 Standard Enhancements

- Core Working Group
 - 2Mbps LE
 - LE long range (LR)
 - Direction finding (AoA/AoD)
 - High output power
 - LE advertising extension
 - Additional advertising channel
 - Adv. frequency hopping
 - High duty cycle non-connectable advertising
 - Smart Mesh Working Group; profile
 - Bluetooth Mesh
- Affected layers (Bluetooth SIG release date)
 - PHY, link layer (2016)
 - Link layer (2016)
 - PHY, link layer (2017)
 - PHY (2016)
 - Link layer (2016)
 - Link layer (2017)
 - Inactive
 - Inactive
 - Profile (2017)

To support requirements of enhancements - direction finding & long range advertising

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Complete Bluetooth Low Energy IP

Low Power PHY on TSMC 40ULP and Link Layer

DesignWare Bluetooth Low Energy PHY IP

- Implements BLE 4.2 and Bluetooth 5.0 features
 - GFSK, 1Mbps (BLE 4.2) & 2Mbps (BT 5.0)
- Supports sub-1V operation
- Excellent performance
- On-chip transceiver matching network
- Interoperable with stacks from vendors
- Supports IEEE.802.15.4
 - 2.4GHz band, O-QPSK, 250kbps, 2.0 MChip/sec
- Evaluation & demonstration boards available
- Also available on TSMC 55ULP
- Delivered as hard IP (GDS)

DesignWare Bluetooth Low Energy Link layer IP

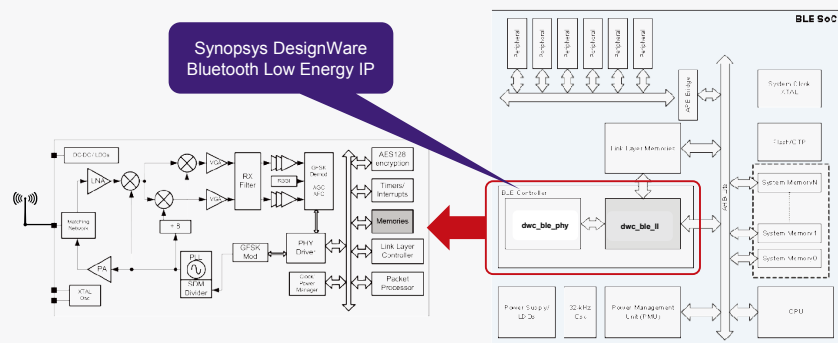
- Supports all features of BLE 4.2
 - 2Mbps data rates (BT 5.0), additional features on roadmap
- Implements HCI interface with stacks
 - Supports several embedded processor architectures & OS
 - Interoperable with stacks from vendors
- Configurable number of concurrent connections & roles
- Implements all required security functions including AES128 encryption engine, random number generator
- Smart HW-FW partitioning for optimal power and area
- Highly optimized power, area, and memory footprint
- Includes design and verification environment
- Delivered as soft IP and firmware

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Complete Bluetooth Low Energy IP

Low Power PHY on TSMC 40ULP and Link Layer

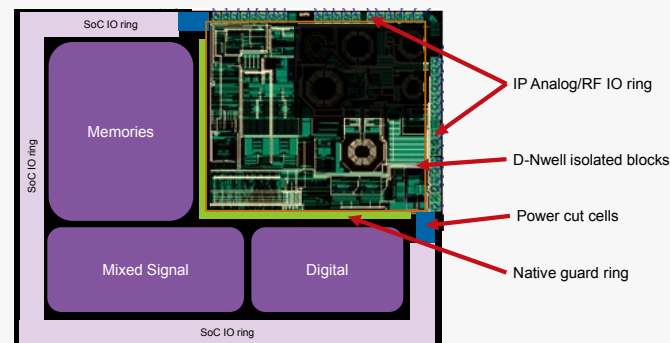


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Fast SoC Integration

Bluetooth Low Energy PHY IP



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Simplified Board Design

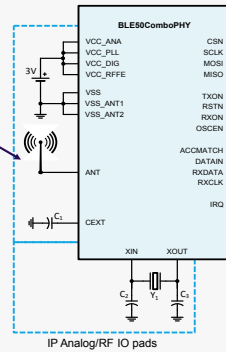
Bluetooth Low Energy PHY IP



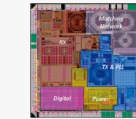
Small BOM

Part Reference	Description
C1	CAP CER 10UF 10V X5R 0603
C2 / C3	CAP CER 9PF 50V NPO 0603
Y1	CRYSTAL 26MHZ 10PF +/- 10ppm SMD

* Supply decoupling capacitors not shown



Comprehensive Validation Procedure From Design to Qualification & Listing



Complete Design Verification Flow



Interoperability Partners

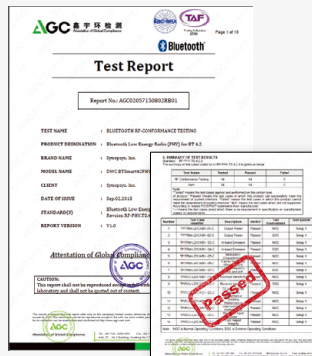


Listing by Bluetooth SIG

Full Characterization PVT corners

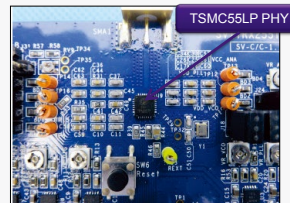
Qualification in Bluetooth Lab

Qualification in Bluetooth Test Facilities

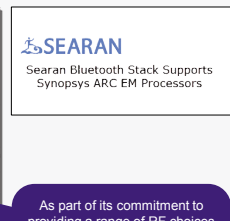
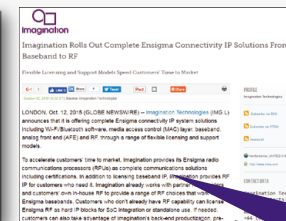


Conformance to BLE 4.2 validated

- All tests "Pass" in corner conditions
- Operating voltage: 0.95V ~ 1.2V
- Operating temp: -40C ~ 85C



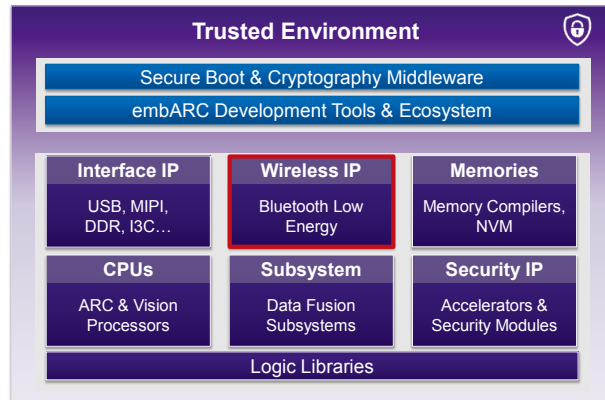
Collaboration with Ecosystem



"Designers prefer complete solutions that minimize product risk and integration effort. Mindtree is pleased to collaborate with Synopsys ... to address this specific need in the Bluetooth technology space."
- said Jayanth Krishna, general manager, short range wireless at Mindtree.

As part of its commitment to providing a range of RF choices that complement Enigma RPU, Imagination has collaborated with Synopsys, a leading provider of high-quality IP solutions.

Synopsys and TSMC Enable IoT Designs



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- Low Power TSMC 40ULP Bluetooth Low Energy PHY
- Bluetooth Link Layer enables complete BLE integration into designs
- Industry's broadest IP portfolio
- Optimized for 55 & 40nm IoT process technologies
- Pre-validated 40-nm IoT Platform through TSMC collaboration

Thank You

synopsys
 Silicon to Software